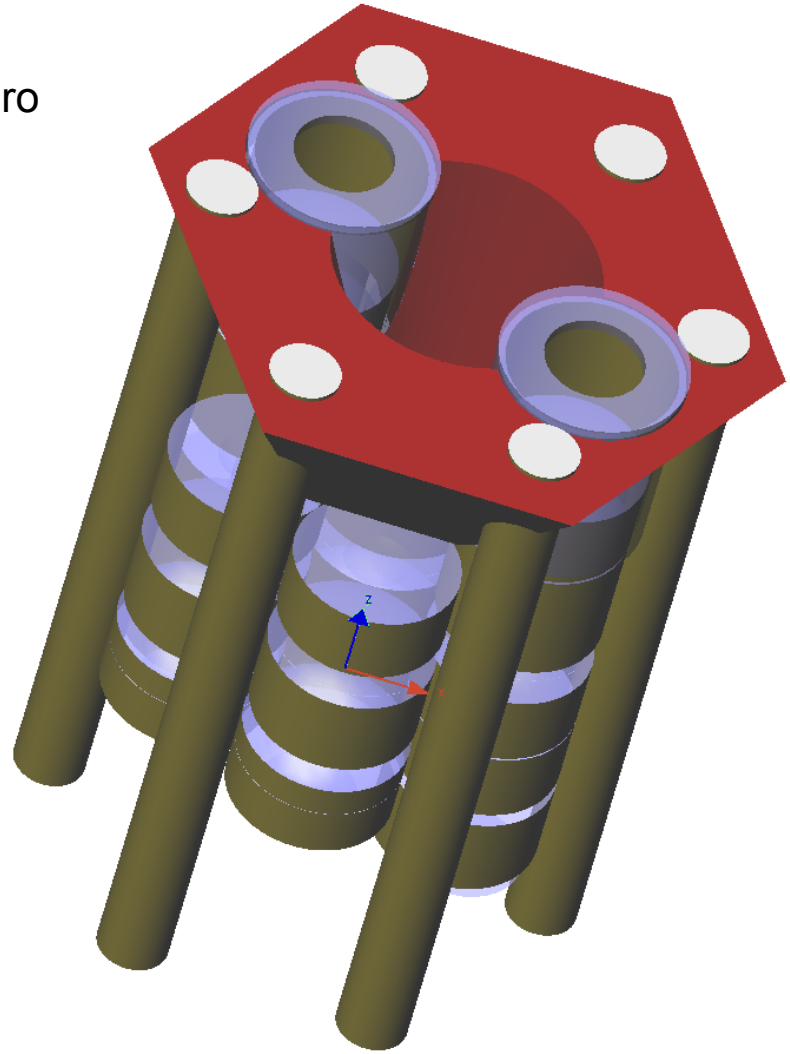
PDV Probe Designed with Stereo Imaging

Robert M. Malone, Brian M. Cata, Thomas H Conwell,
Brent C. Frogget, Morris I. Kaufman, and Vincent T. Romero

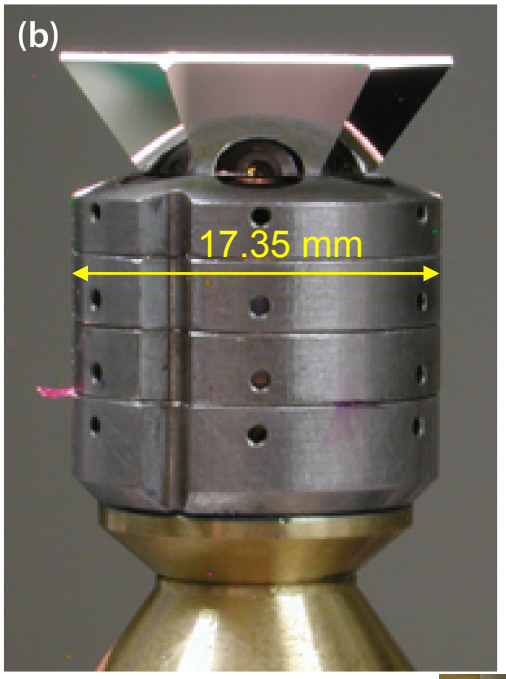
National Security Technologies, LLC
Los Alamos Operations
P.O. Box 809, Los Alamos, NM 87544

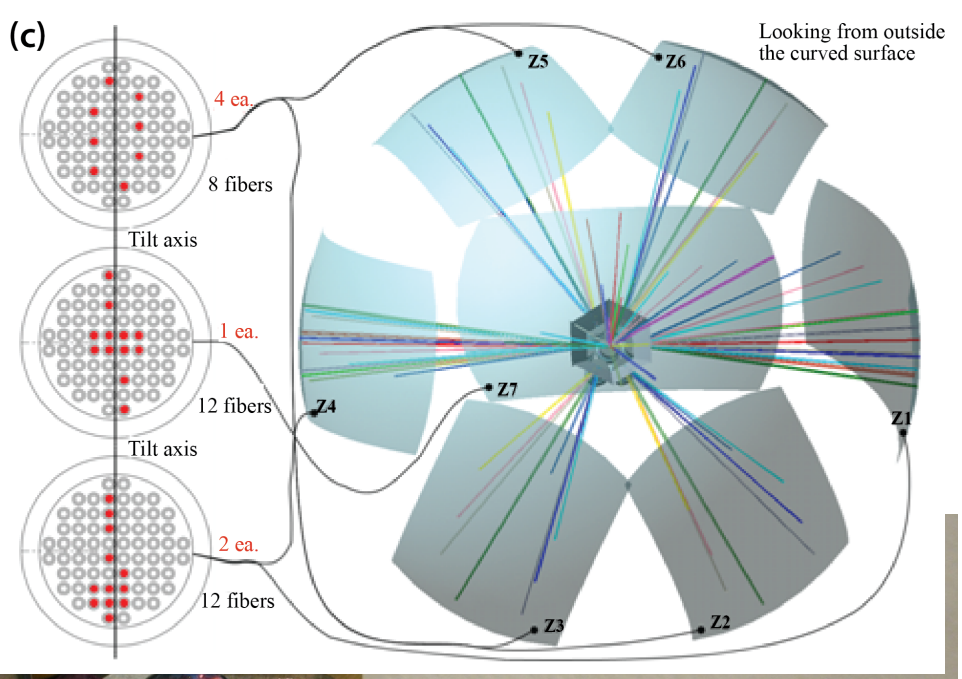


For 8th Annual PDV Workshop
June 24-26, 2014
Las Vegas, NV

This work was done by National Security Technologies, LLC, under
Contract No. DE-AC52-06NA25946 with the U.S. Department of Energy.

Multiple lens array probe for hemisphere experiments, 9/2011



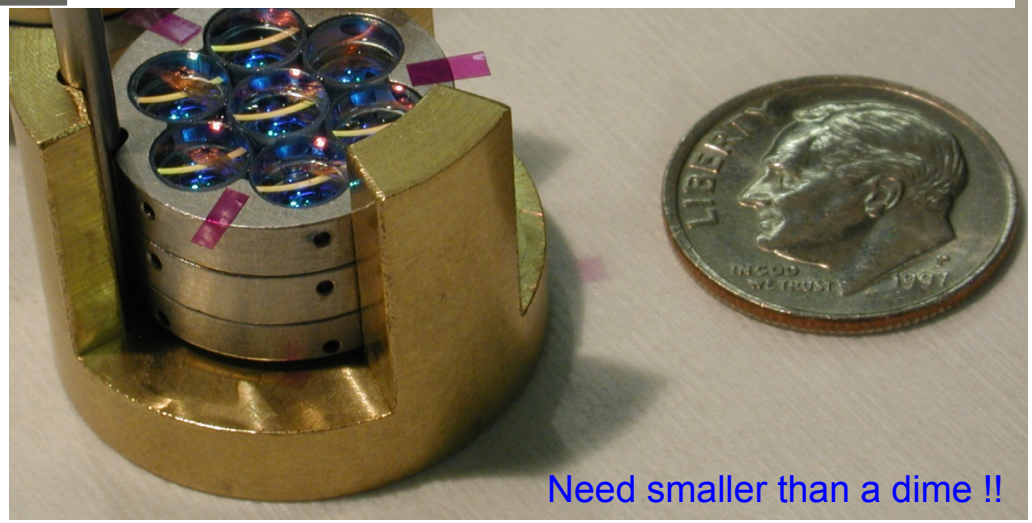


Using 4 mm diameter lenses

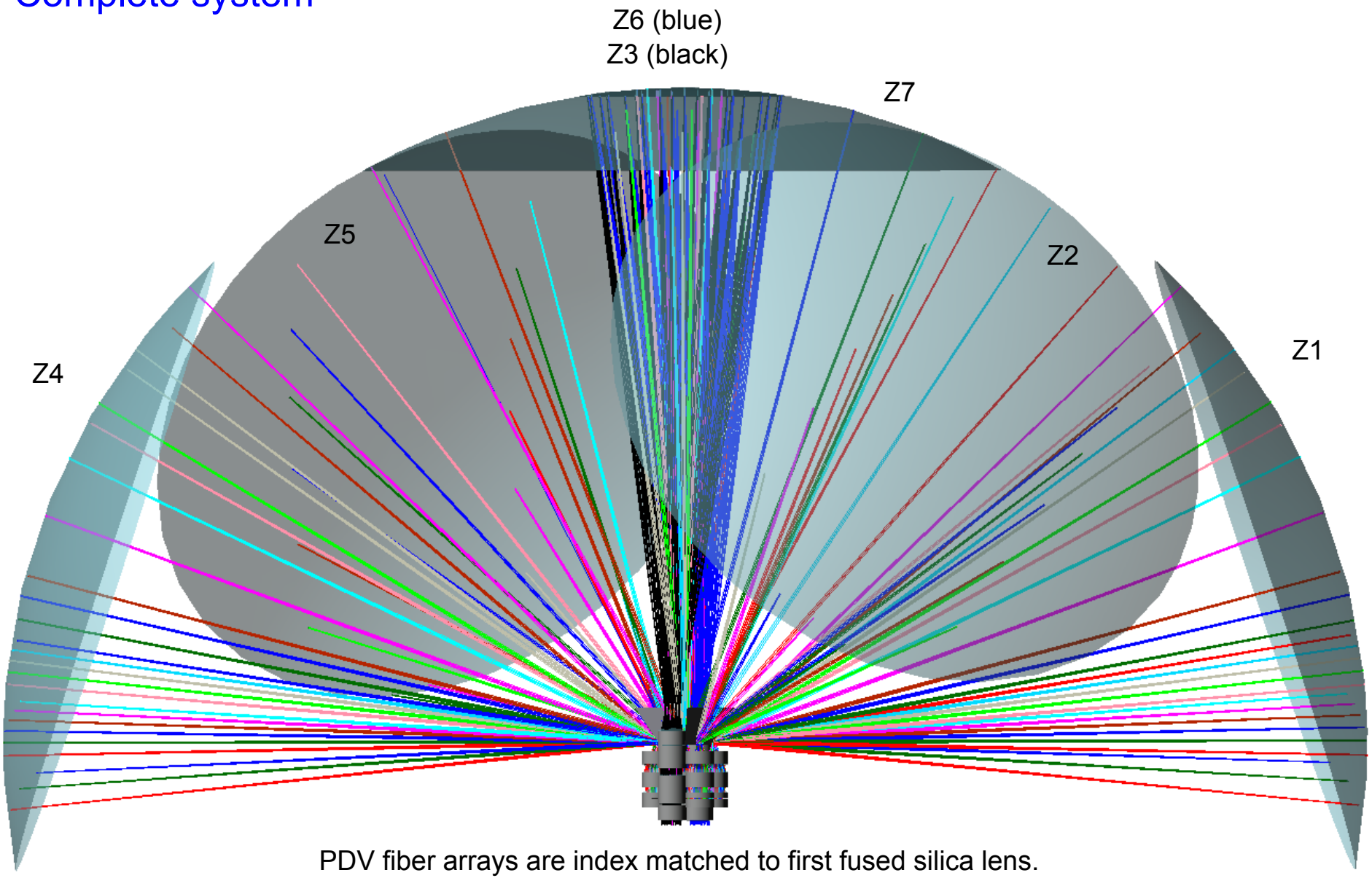
(a) Without multi-faceted prism

(b) With prism

(c) Fiber points in zone coverage (zone positions can be changed if prism face angles are changed or zones rotated)



Complete system



PDV fiber arrays are index matched to first fused silica lens.

Zones 3 & 6 are used for stereo imaging

The stop diameter determines the NA of collected light and also the depth of focus

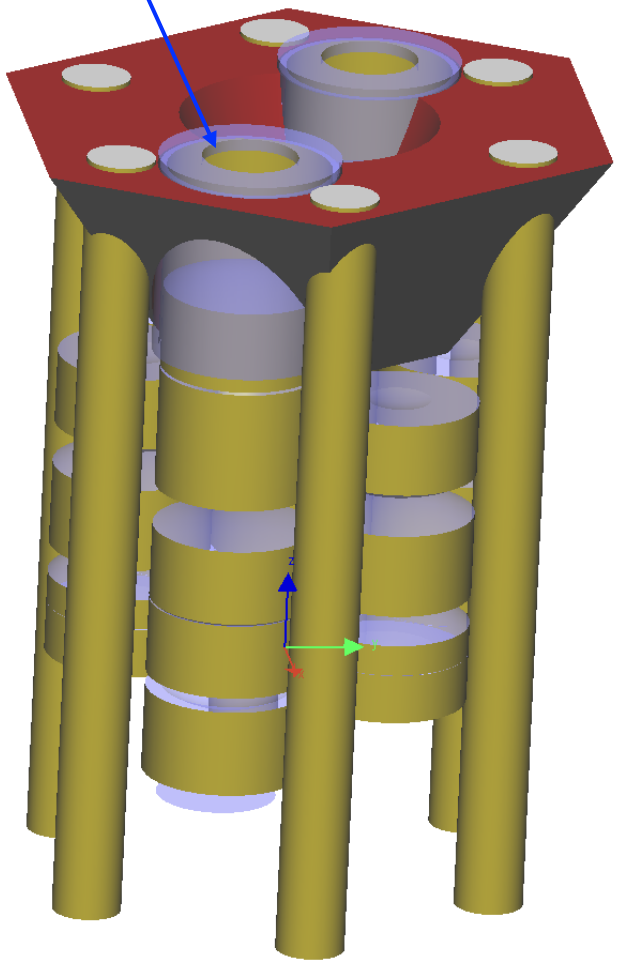
(Perspective has been rotated)

Z6 (blue)
Z3 (black)

24 mm diameter zone for imaging (blue & black rays); 10x magnification

F/# of surface collected light is 36

Imaging stop

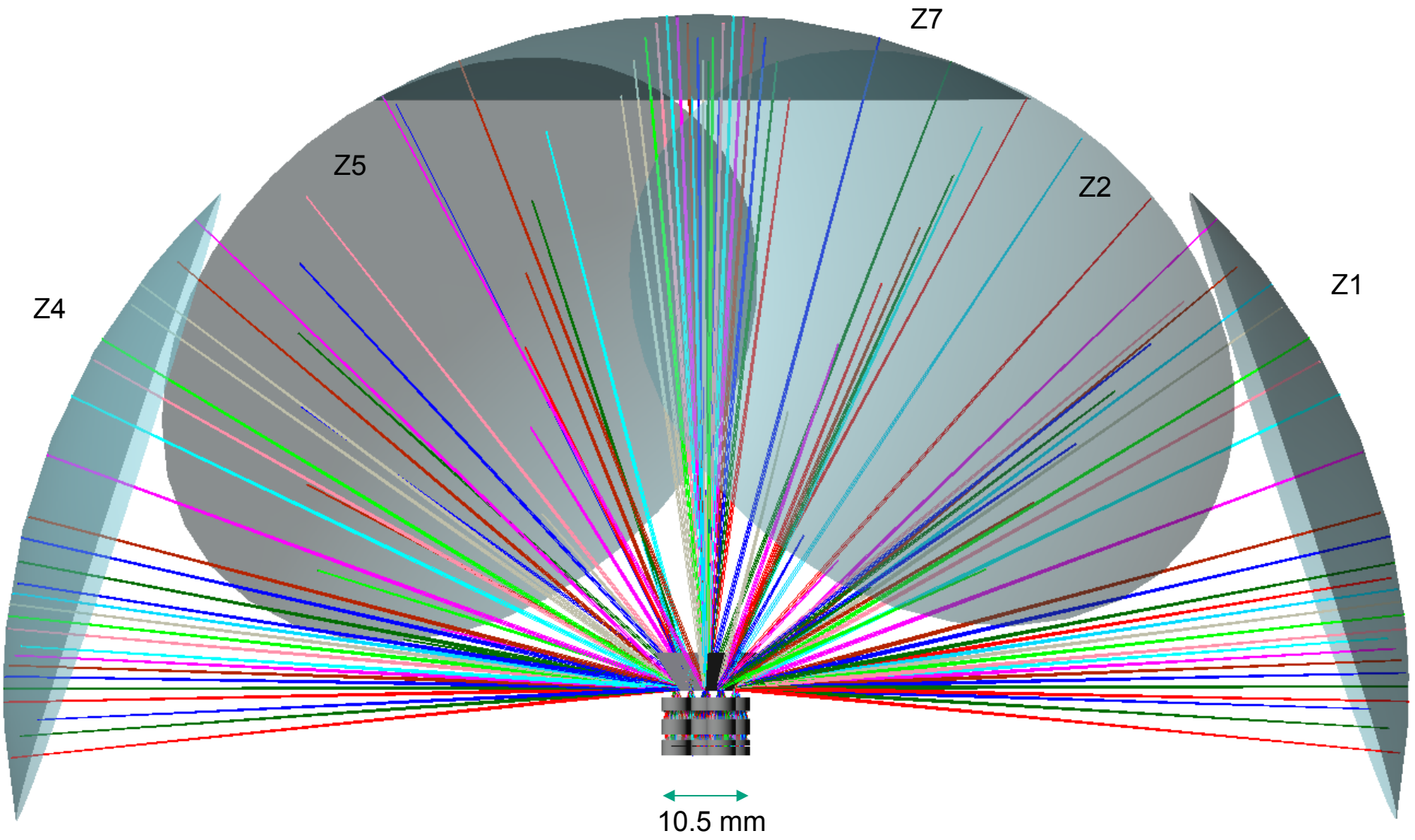


Assuming 24 mm diameter FOV at surface and 2.4 mm diameter bundle at 50 lp/mm. Resolve 200 µm at surface (5 lp/mm).

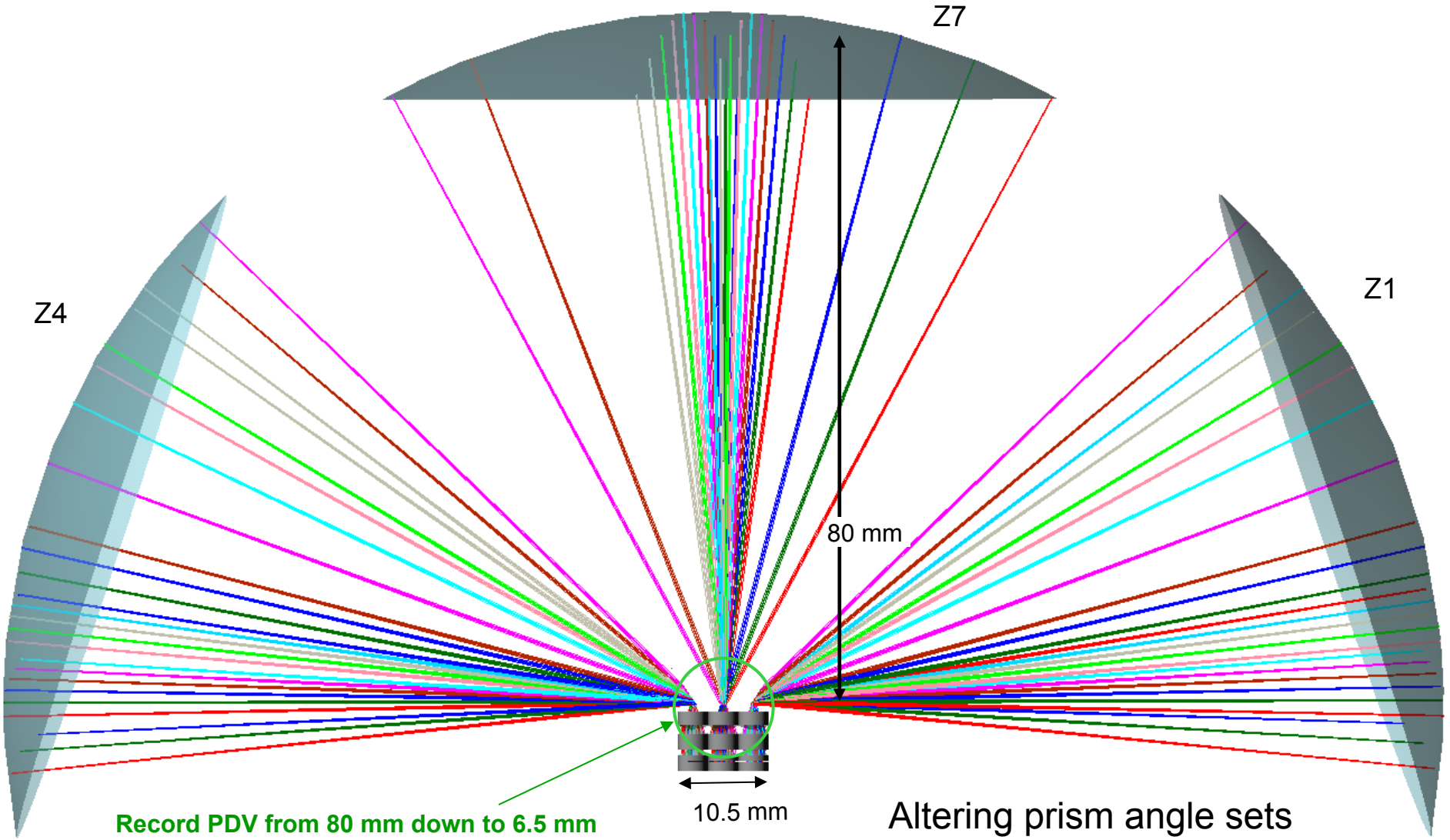
2 thin stop "washers" rest on top of prism

Coherent bundles are translated 0.314 mm, so that the image areas overlap.

PDV only system

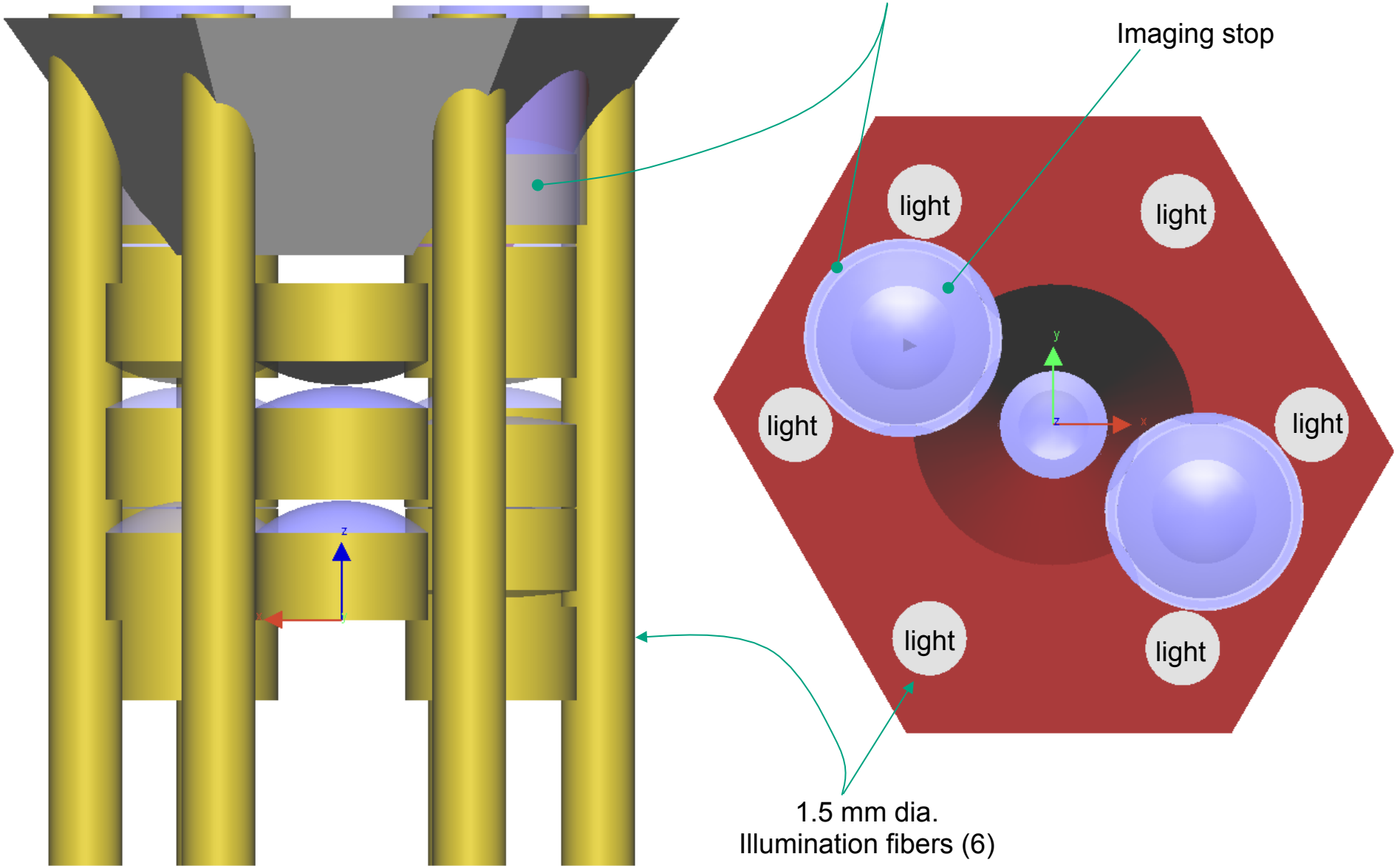


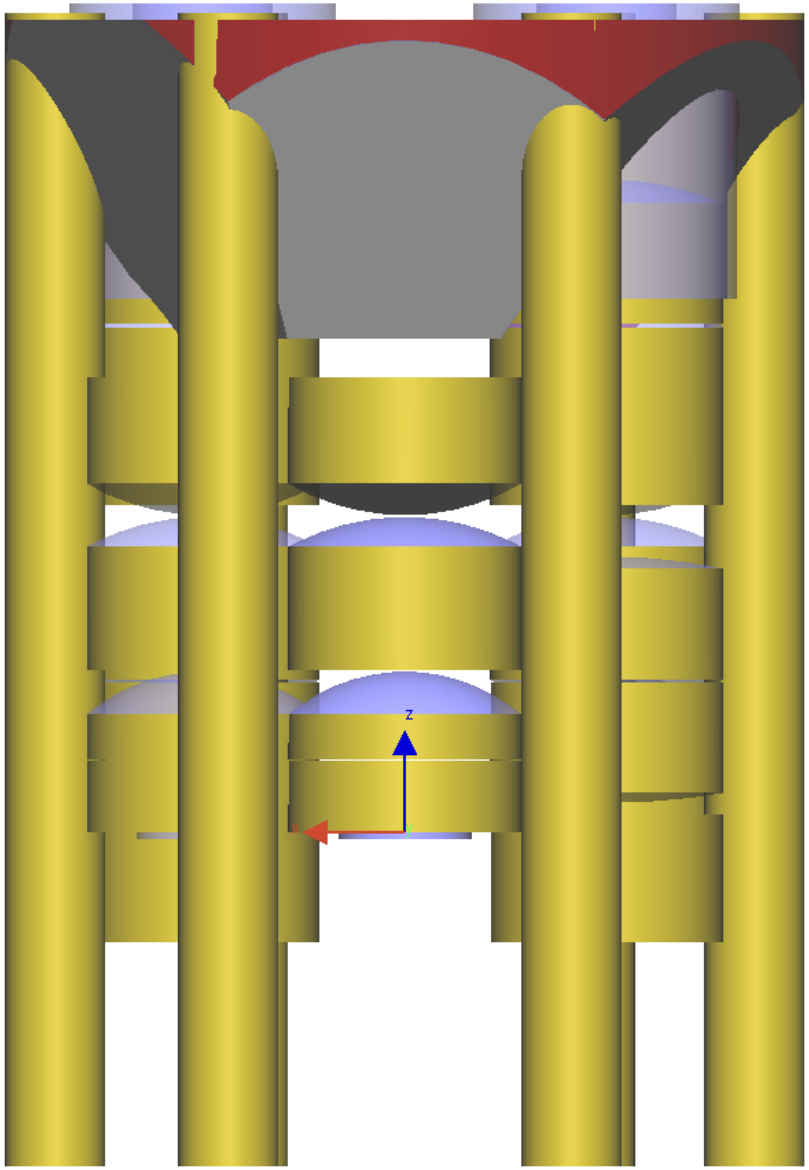
Partial PDV system



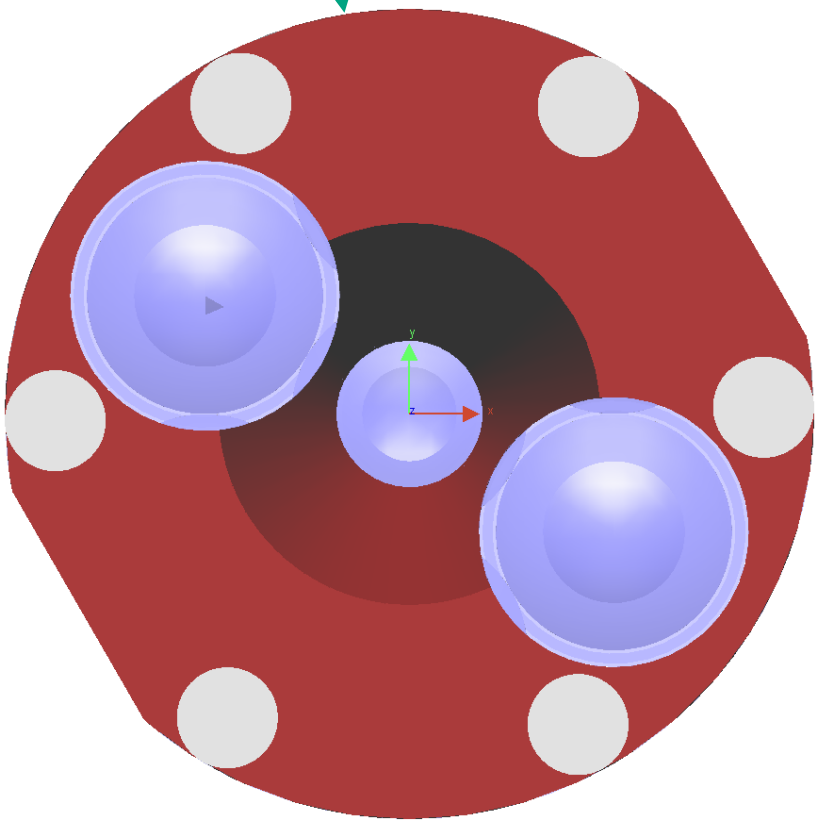
Altering prism angle sets viewing below the horizon

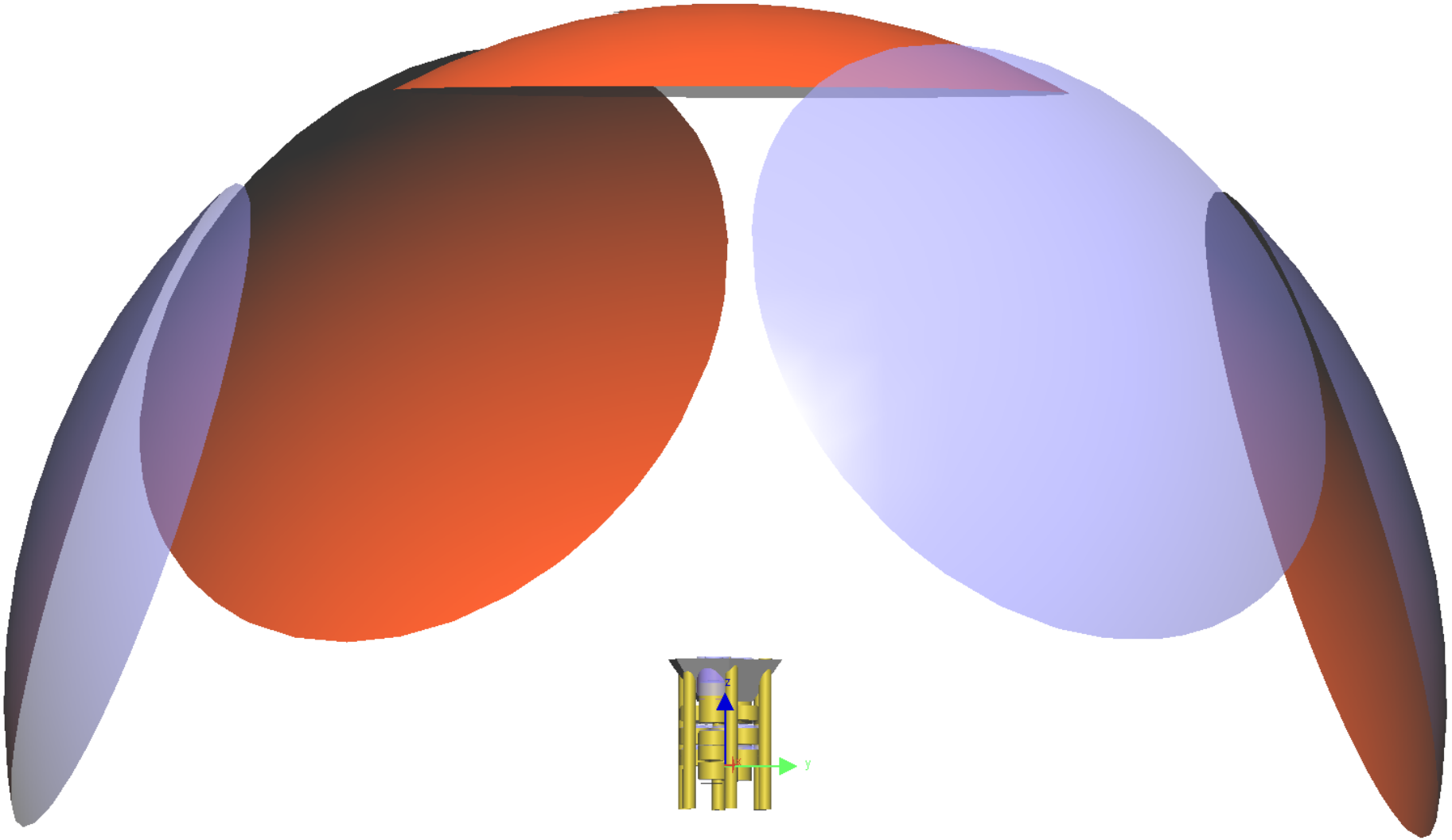
2 prism facets are tilted at 56° and 4 at 61°

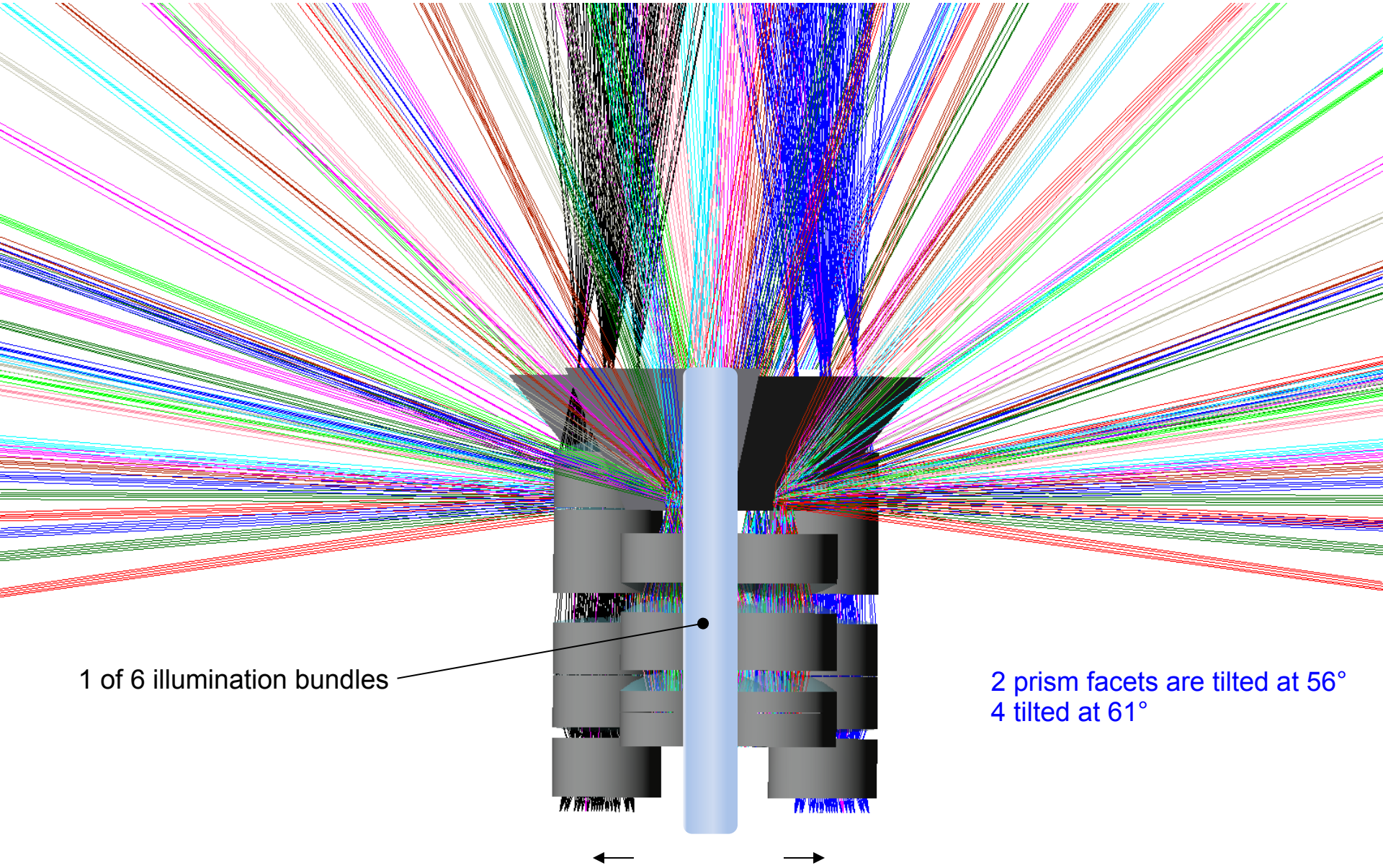




Edges of prism trimmed to 12 mm diameter




z
y


1 of 6 illumination bundles
2 prism facets are tilted at 56°
4 tilted at 61°
Coherent bundles offset to allow overlap imaging

Placing 2 of the 2.5 mm diameter bundles plus 6 of the 1.5 mm illumination bundles leaves room for **>346 PDV fibers** (ignoring fibers that touch anything).
AOC probe can only image 2.4 mm diameter.
Cutoff switches line the inside of the 6.5 mm ID pipe.

FIBER PACKING PROGRAM DATA

Output Data

Packed fiber number =2017

Packing Configuration

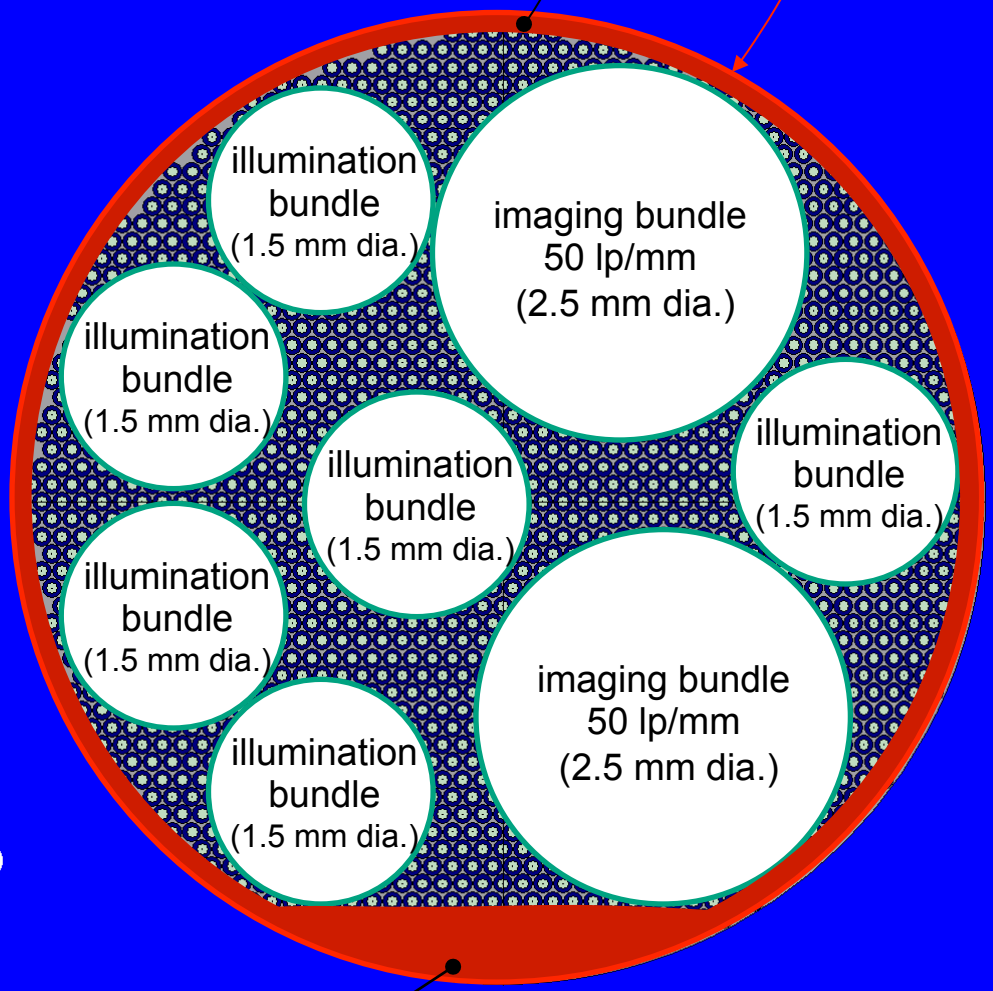
Hexagonal Close Pack

Input Data

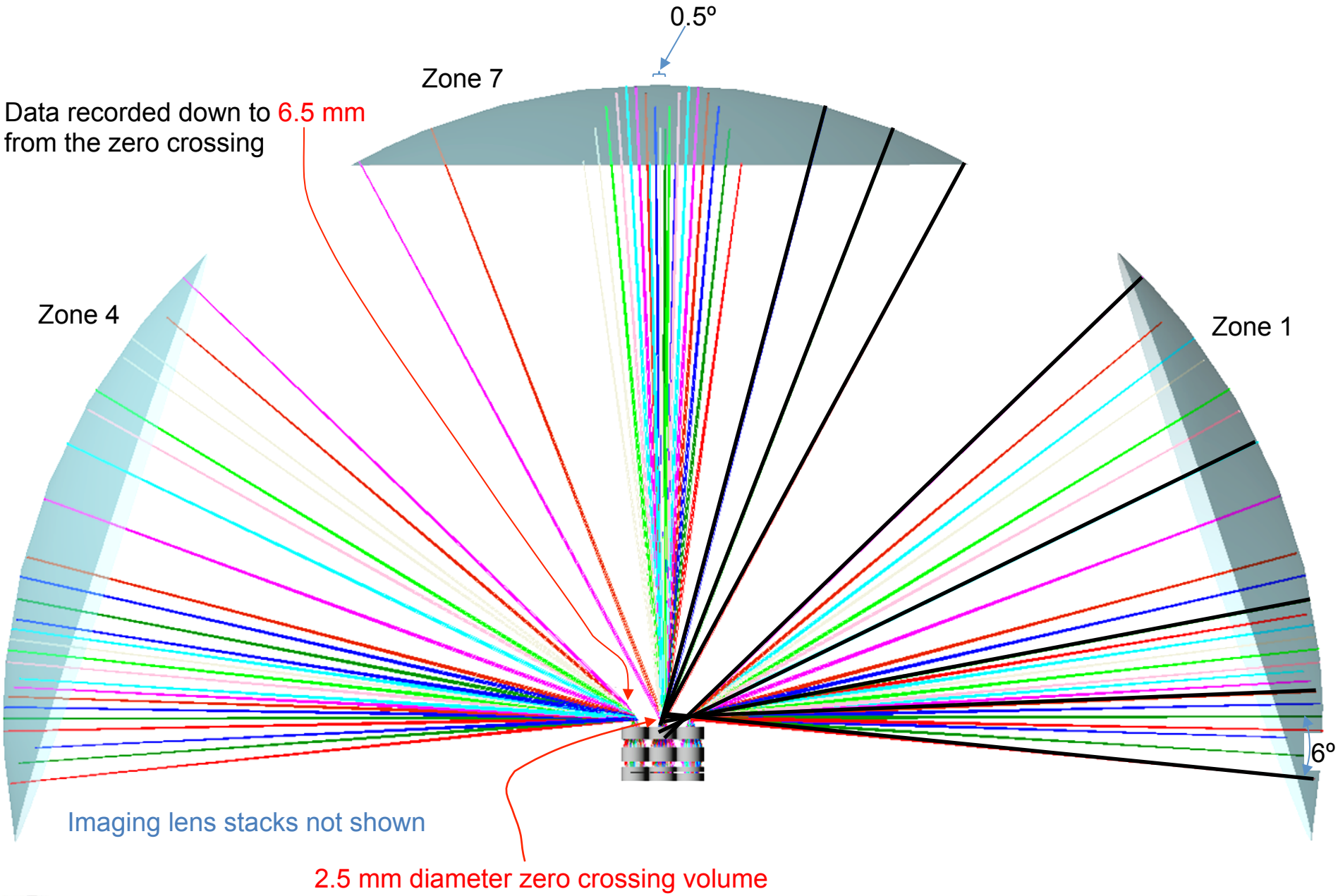
Tube Diameter (mm)	=6.5
Coating Diameter (um)	=135
Cladding Diameter (um)	=80
Core Diameter (um)	=10

Area (Square mm)

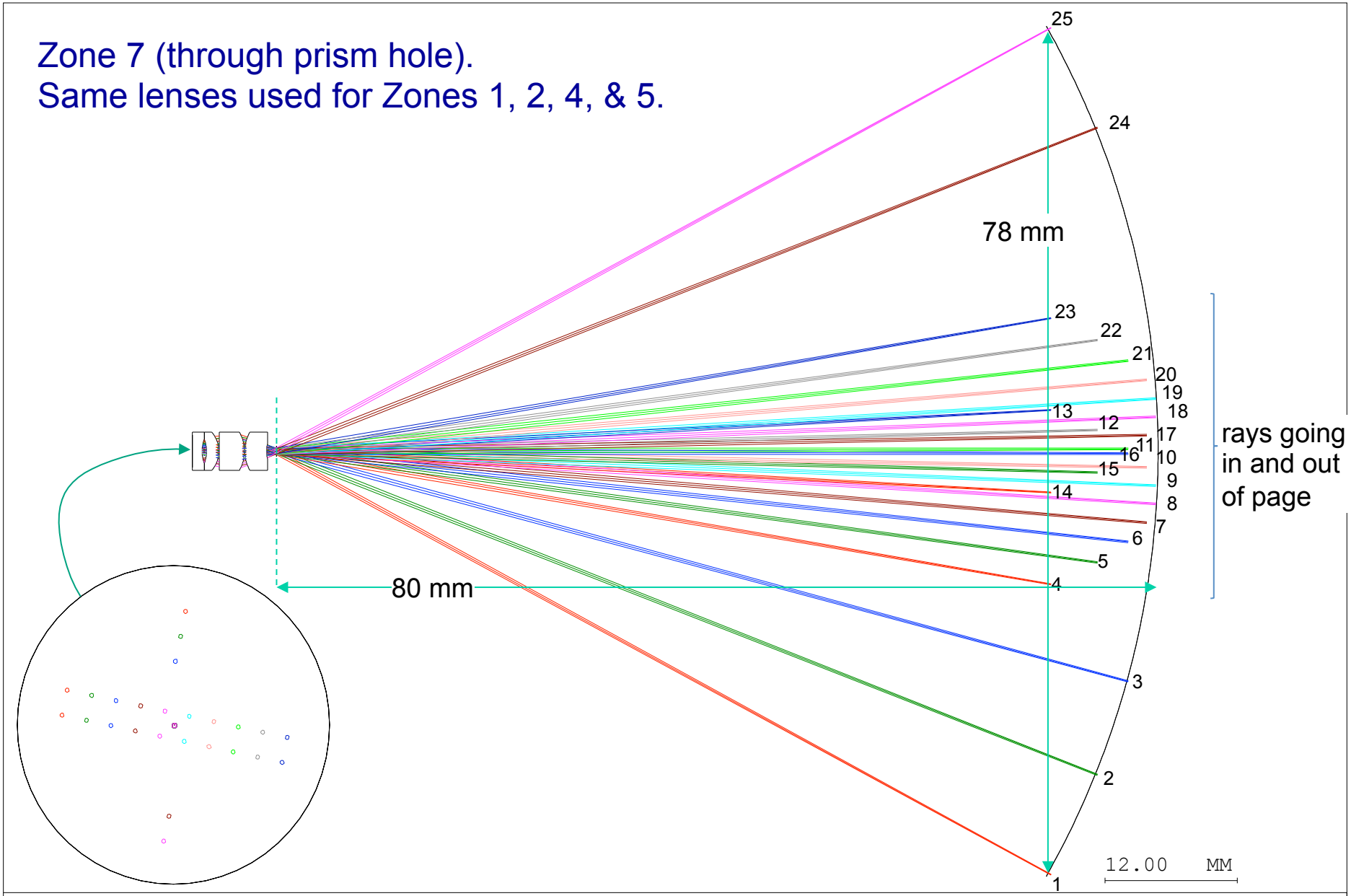
Tube	=33.18	
Coating	=18.73	(56.5%)
Cladding	=9.98	(30.1%)
Core	=0.1584	(0.477%)
Dead Area	=4.312	(13%)



Direction vectors of beam trajectories



Zone 7 (through prism hole).
Same lenses used for Zones 1, 2, 4, & 5.

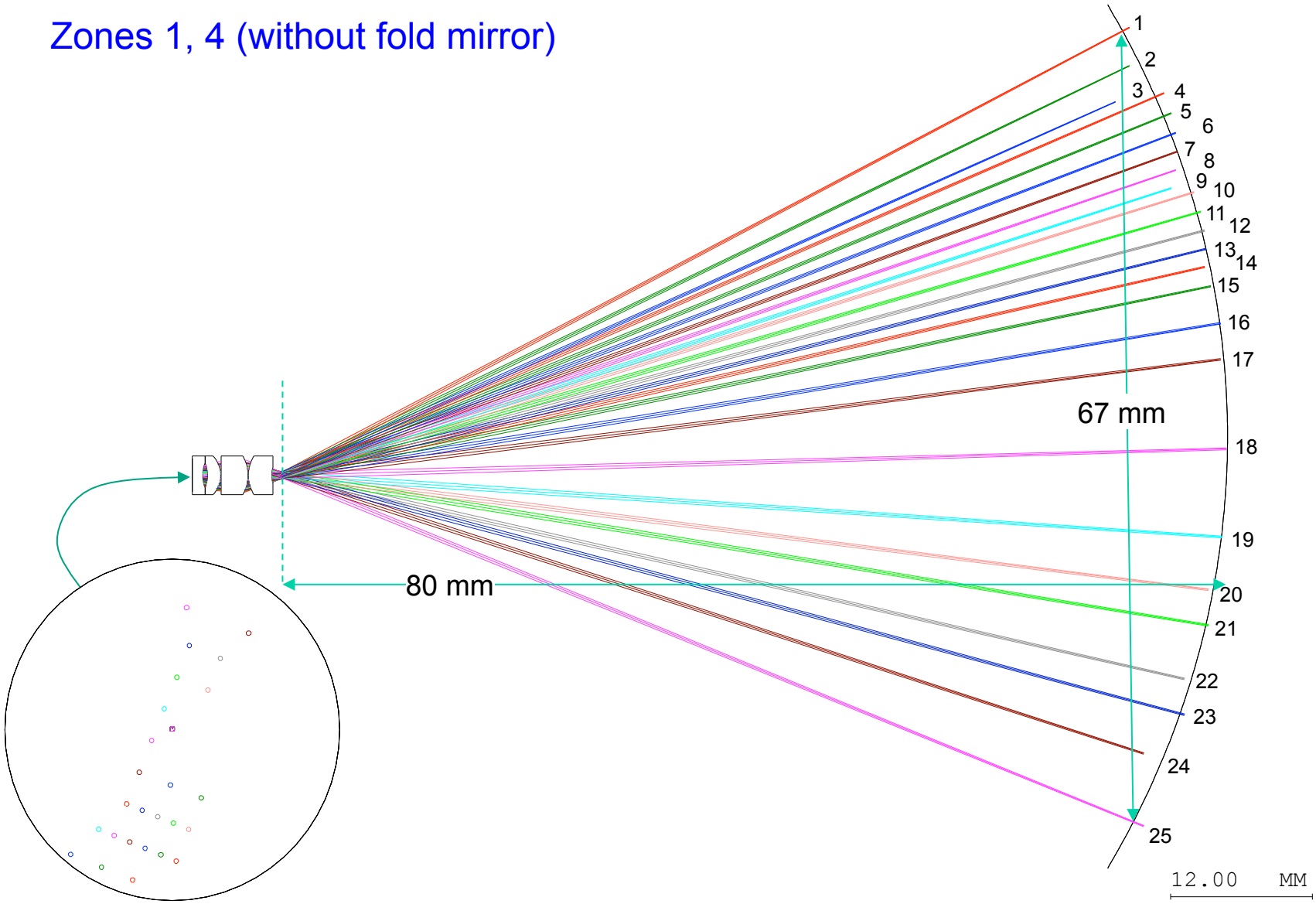


AOC_V61_Z7.len

Fiber array has been rotated 11.9°

RMM 12-Jun-14

Zones 1, 4 (without fold mirror)

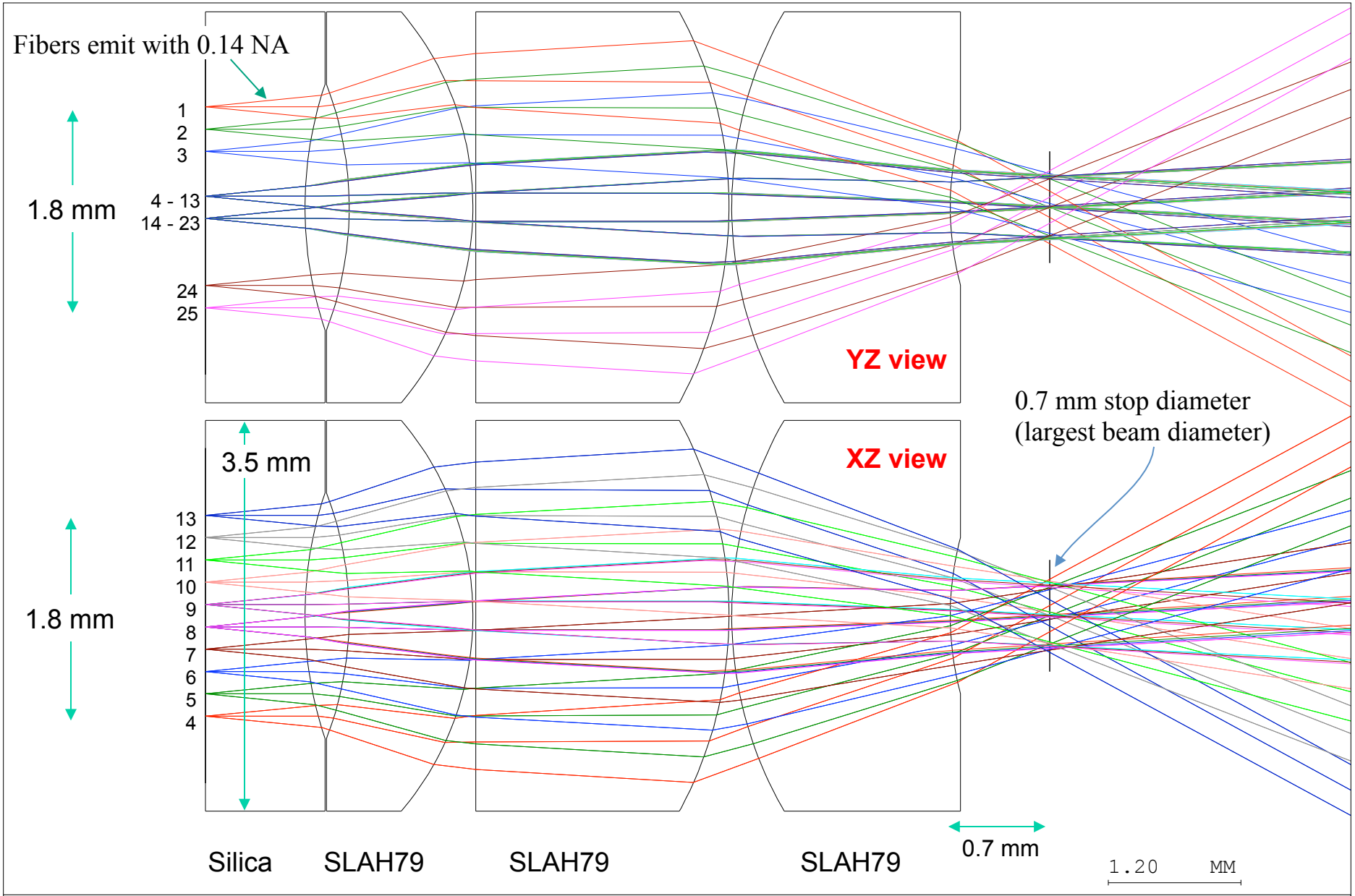


AOC_V61_Z1.len

Fiber array has been rotated 22°

RMM 12-Jun-14

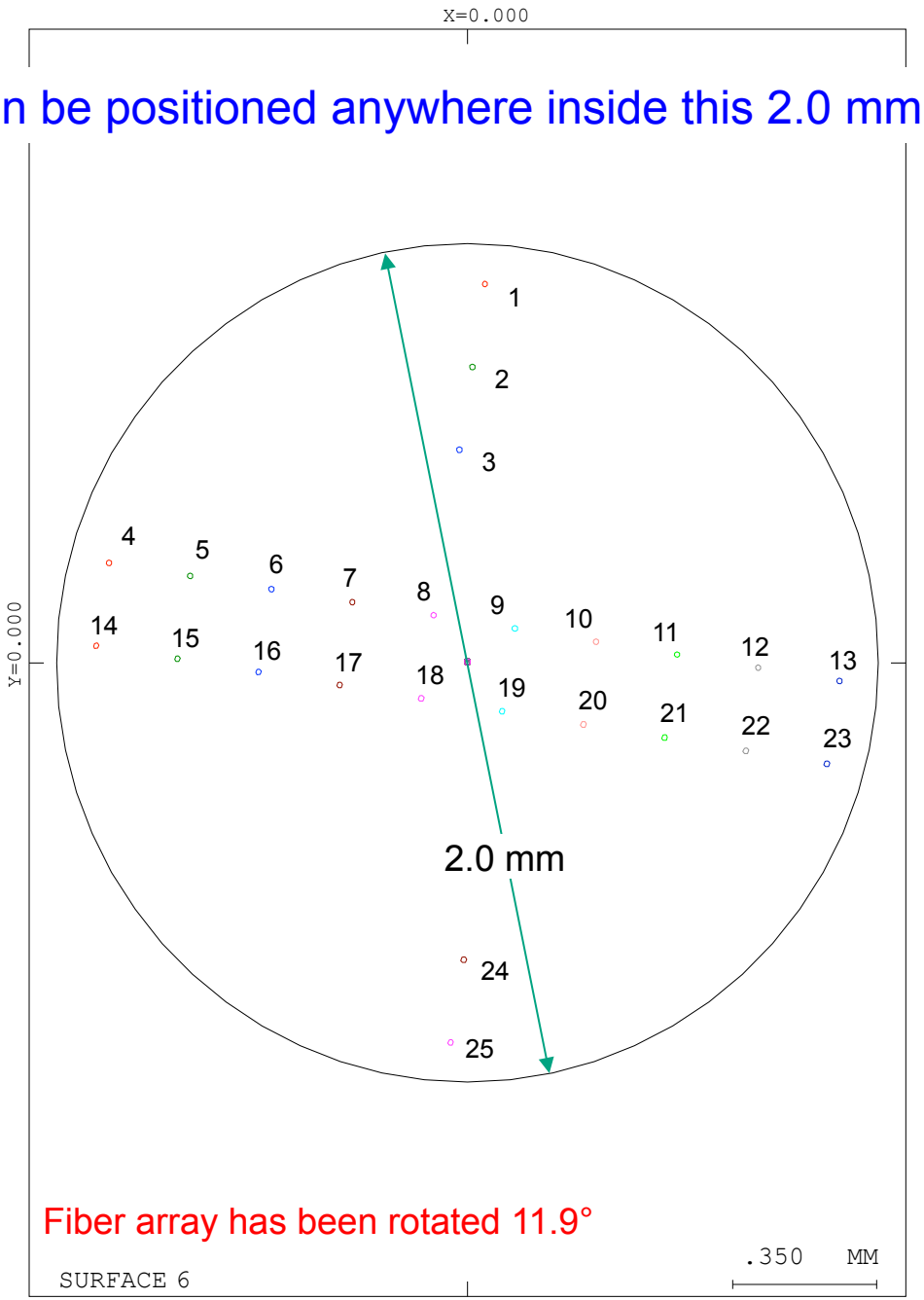
Index matching fibers to 1st optical element



AOC_V61_Z7.len

RMM 12-Jun-14

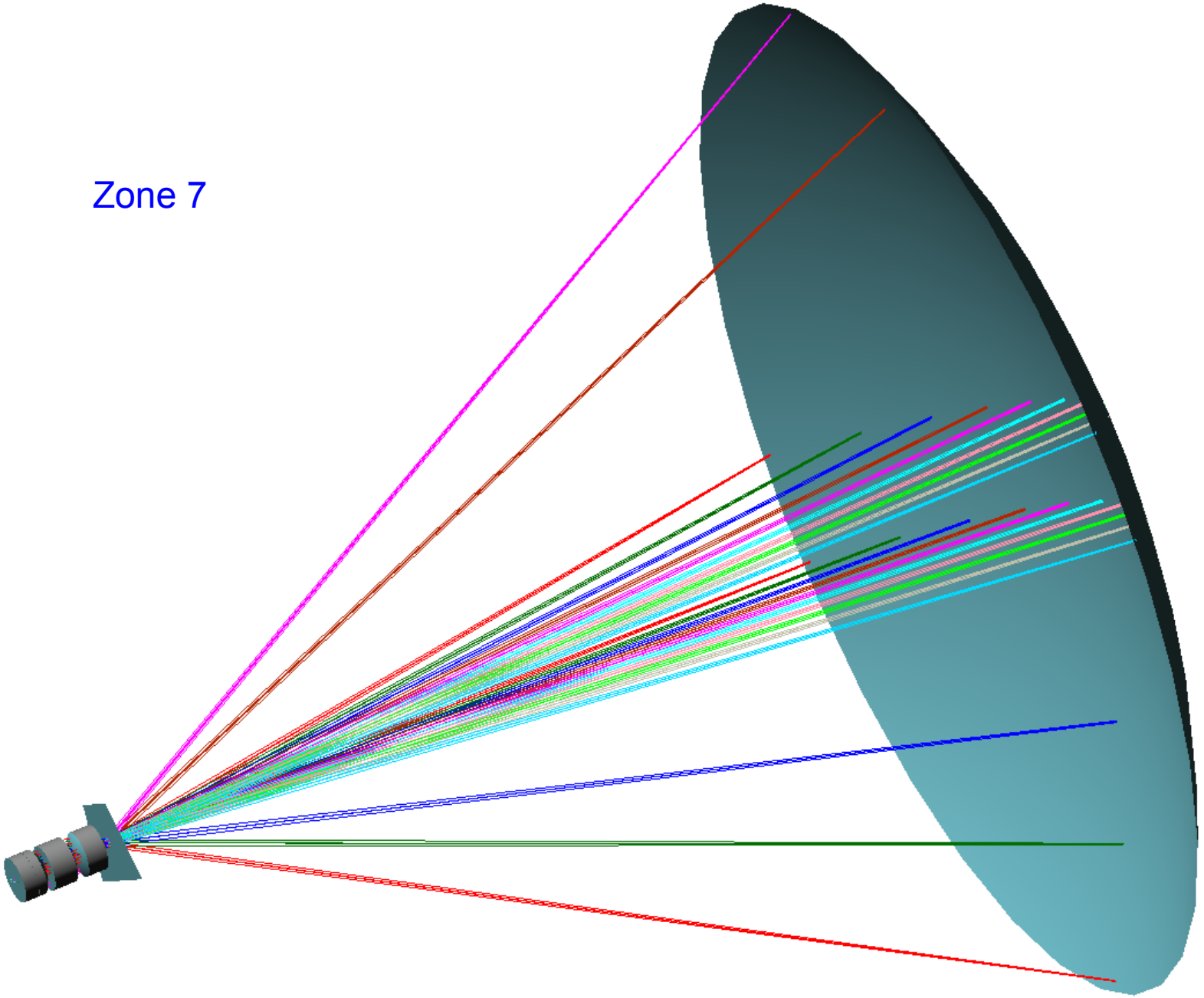
Fibers can be positioned anywhere inside this 2.0 mm diameter circle



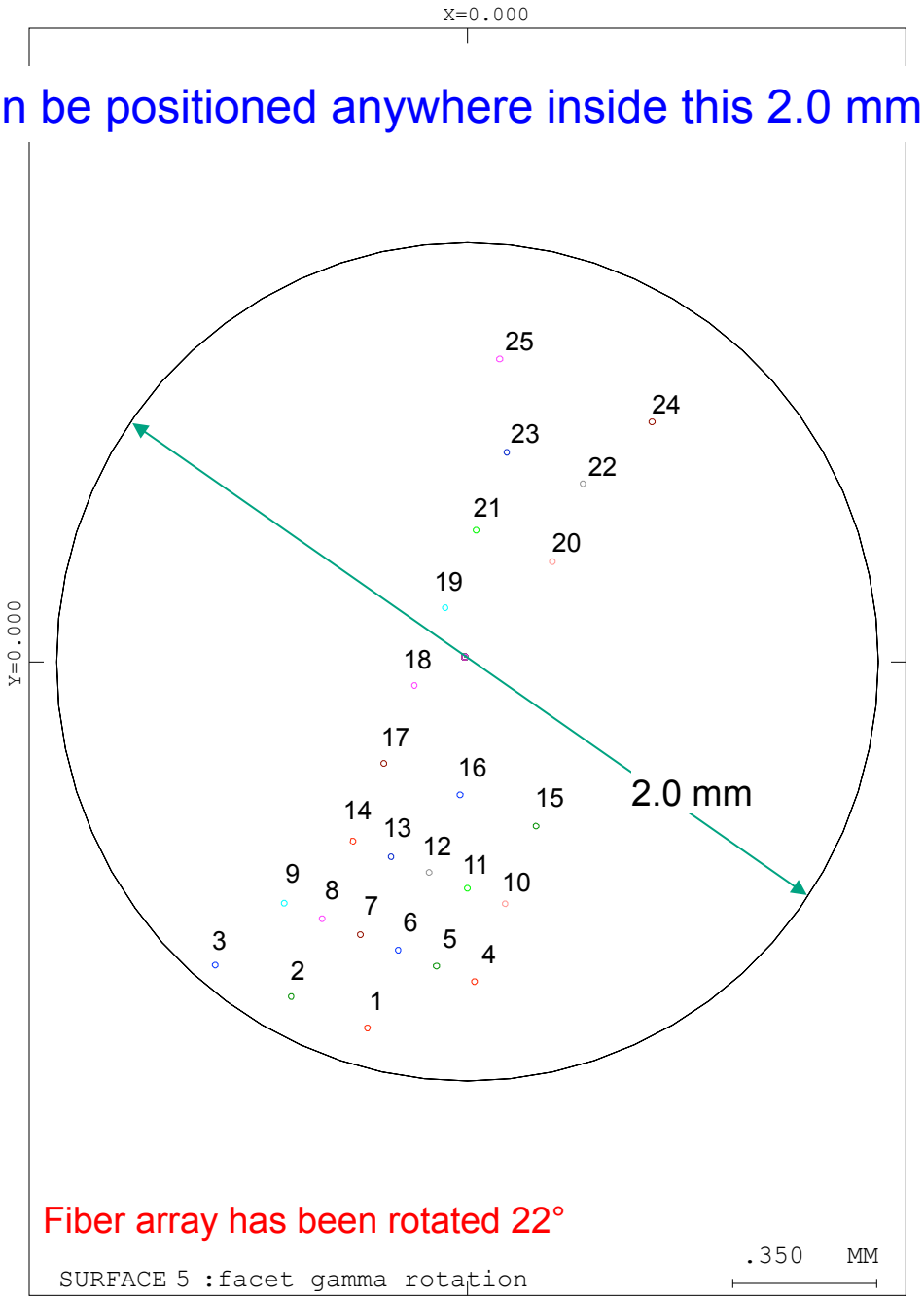
Zone 7

Fiber array has been rotated 11.9°

Zone 7



Fibers can be positioned anywhere inside this 2.0 mm diameter circle



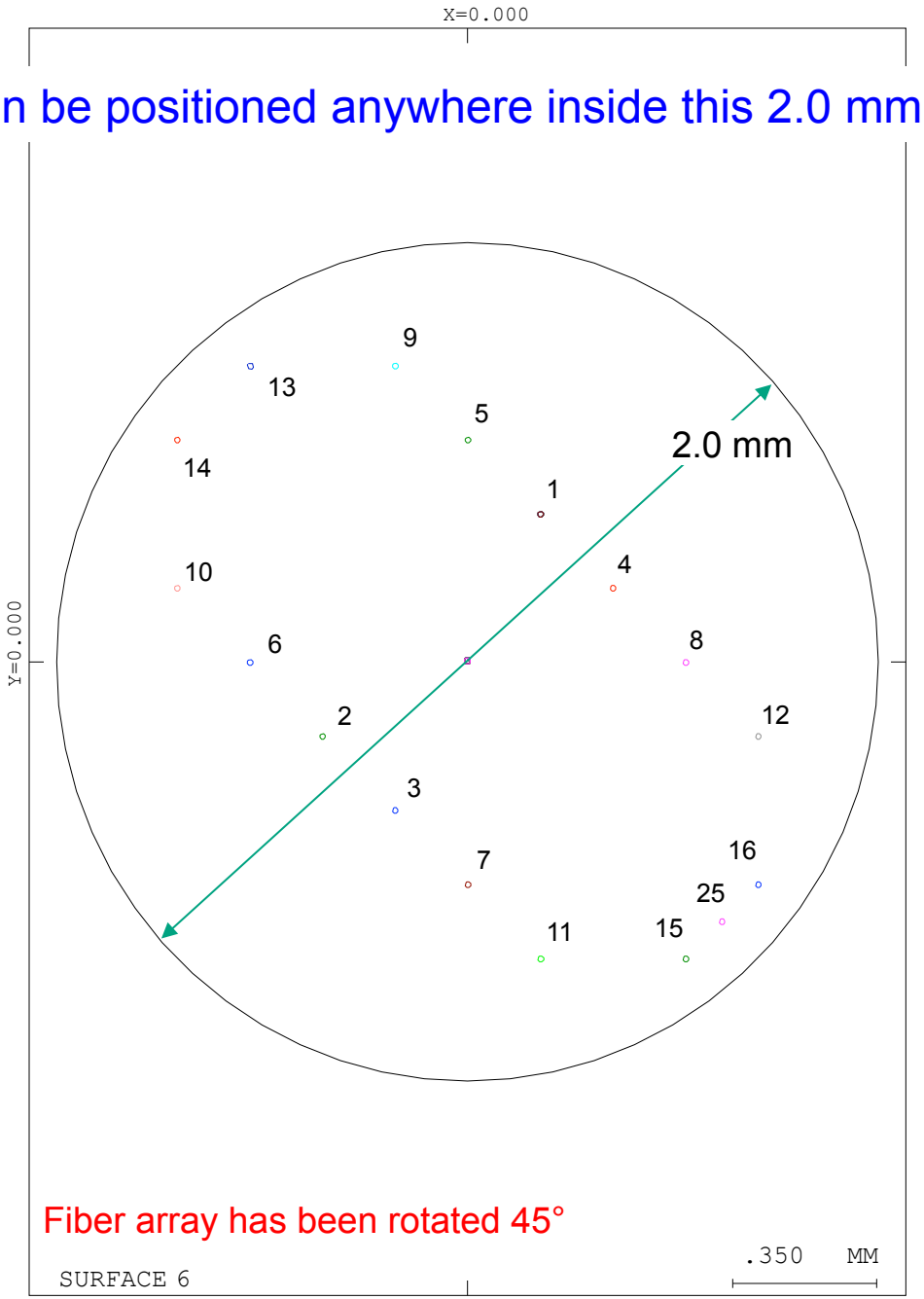
Zones 1, 4

Fiber array has been rotated 22°

RMM 17-Jun-14

AOC V61 Z1.len

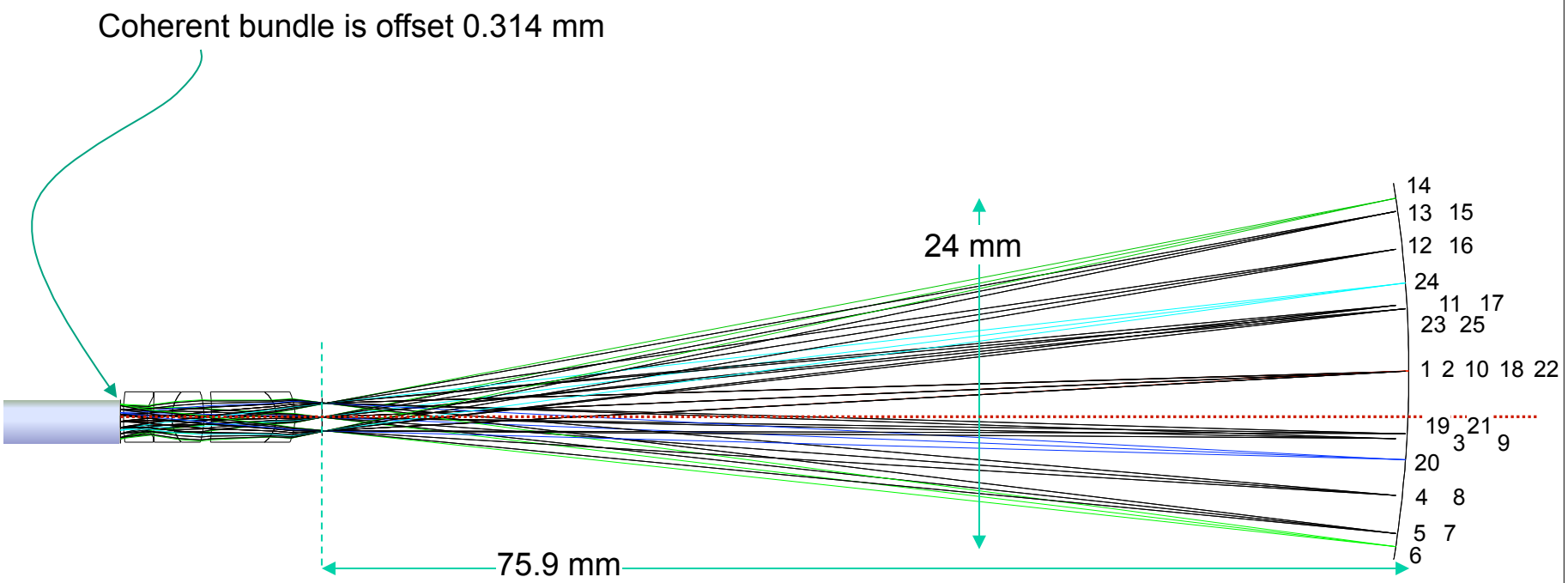
Fibers can be positioned anywhere inside this 2.0 mm diameter circle



Zones 2, 5

Fiber array has been rotated 45°

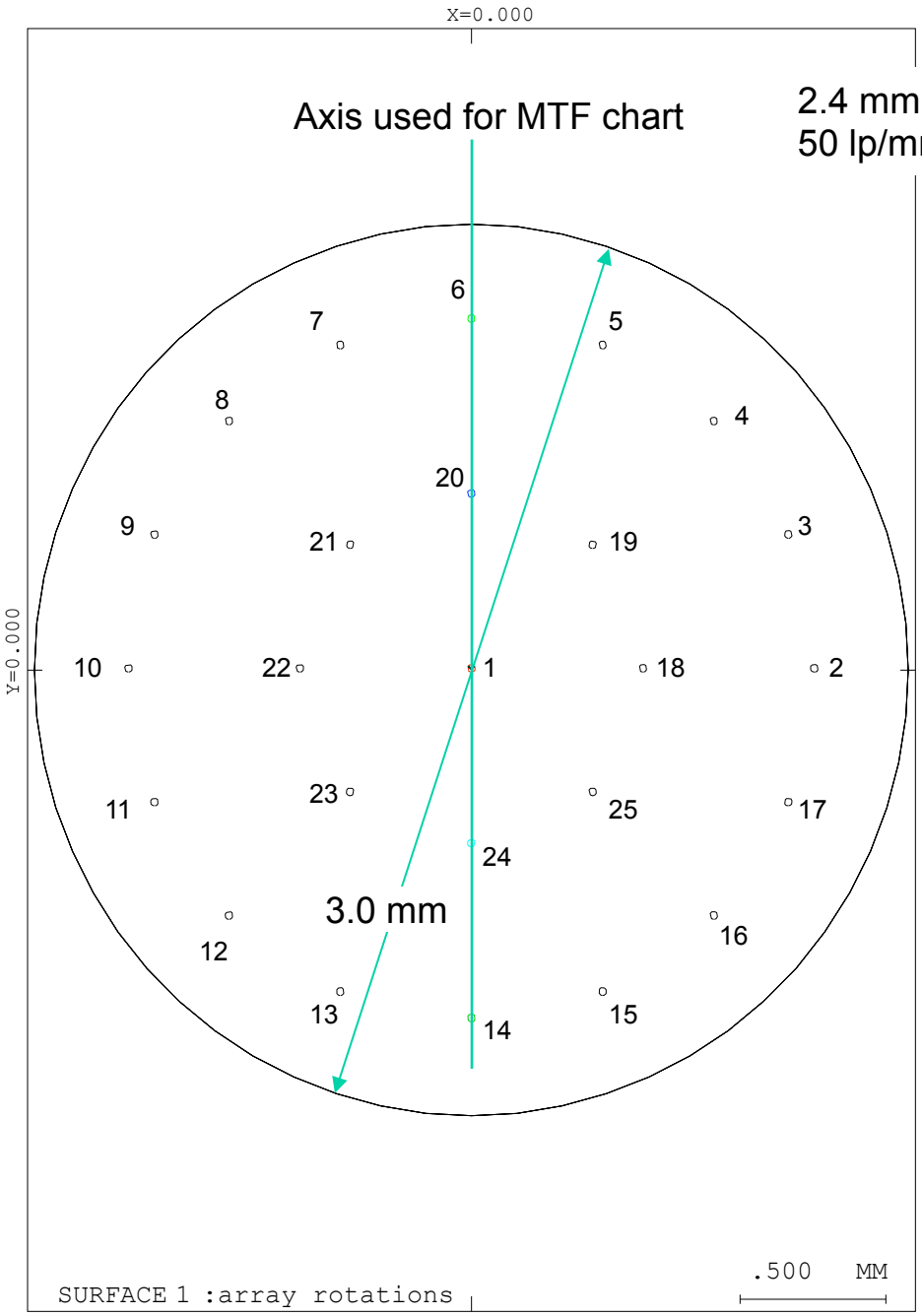
Zones 3 & 6 are used for stereo imaging (500–700 nm)



AOC_V61_Z3_imaging.len

RMM 12-Jun-14

Imaging Details

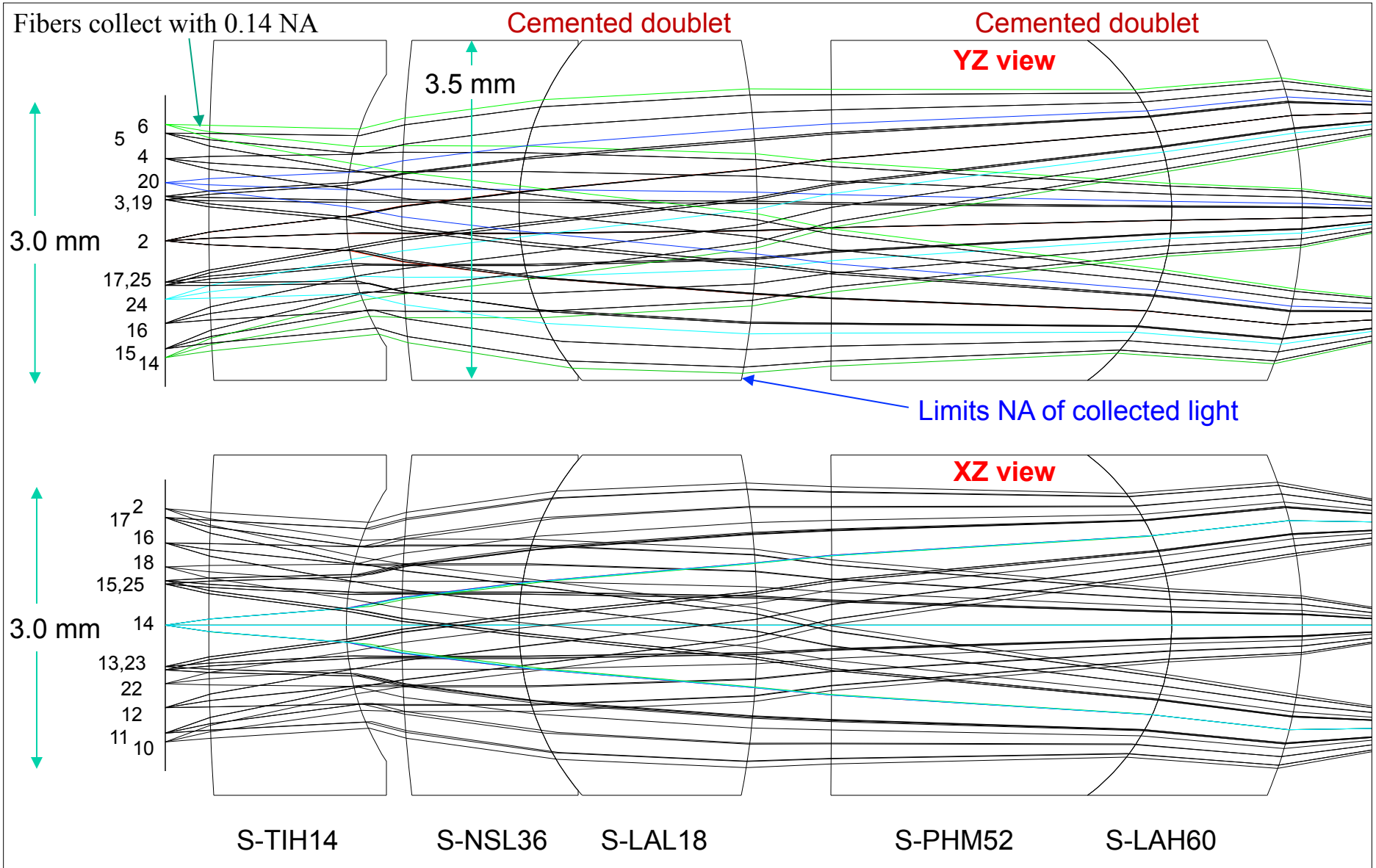


2.4 mm diameter image area
50 lp/mm resolution of coherent bundle

Zones 3, 6

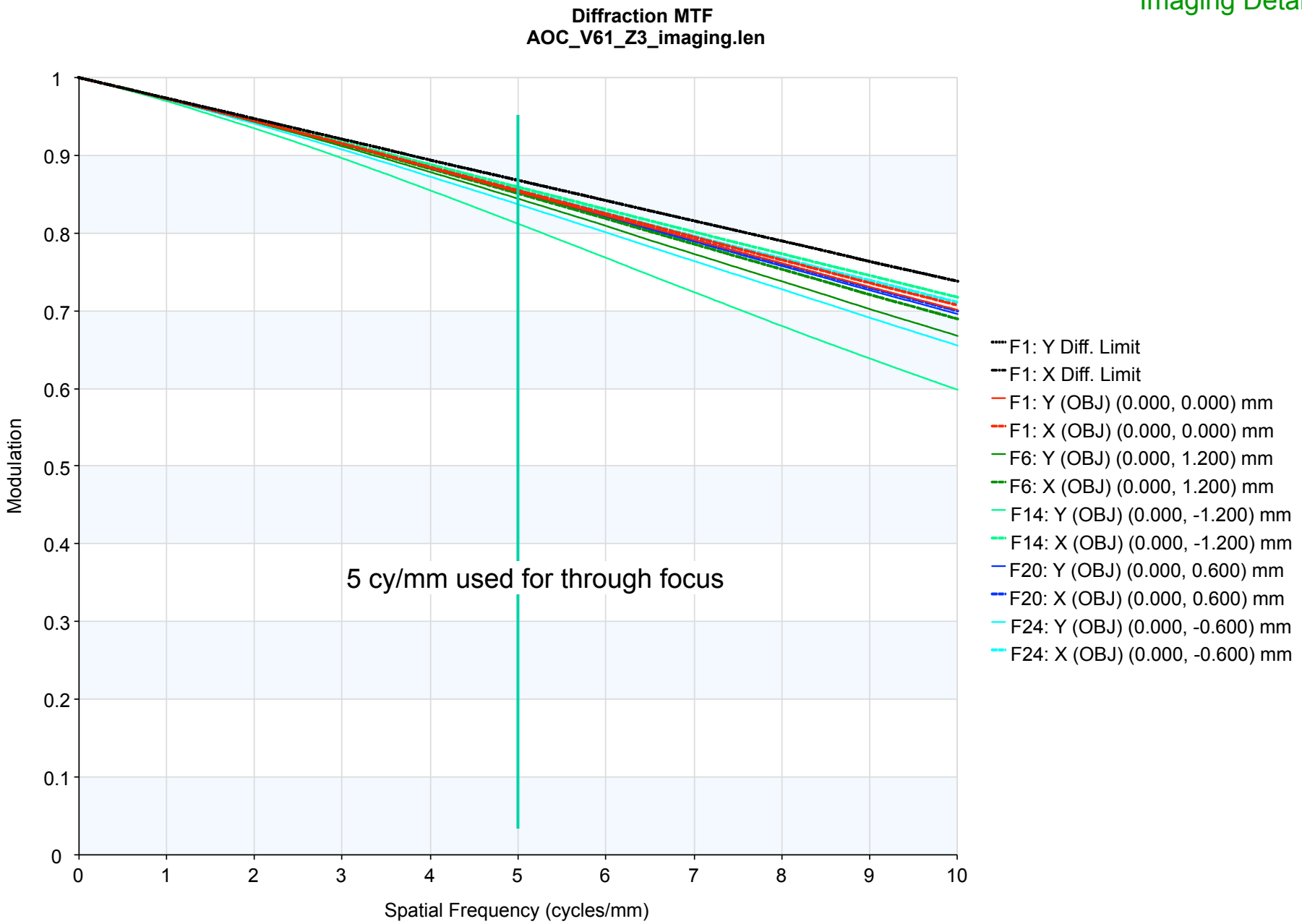
RMM 12-Jun-14

AOC V61 Z3 imaging.len

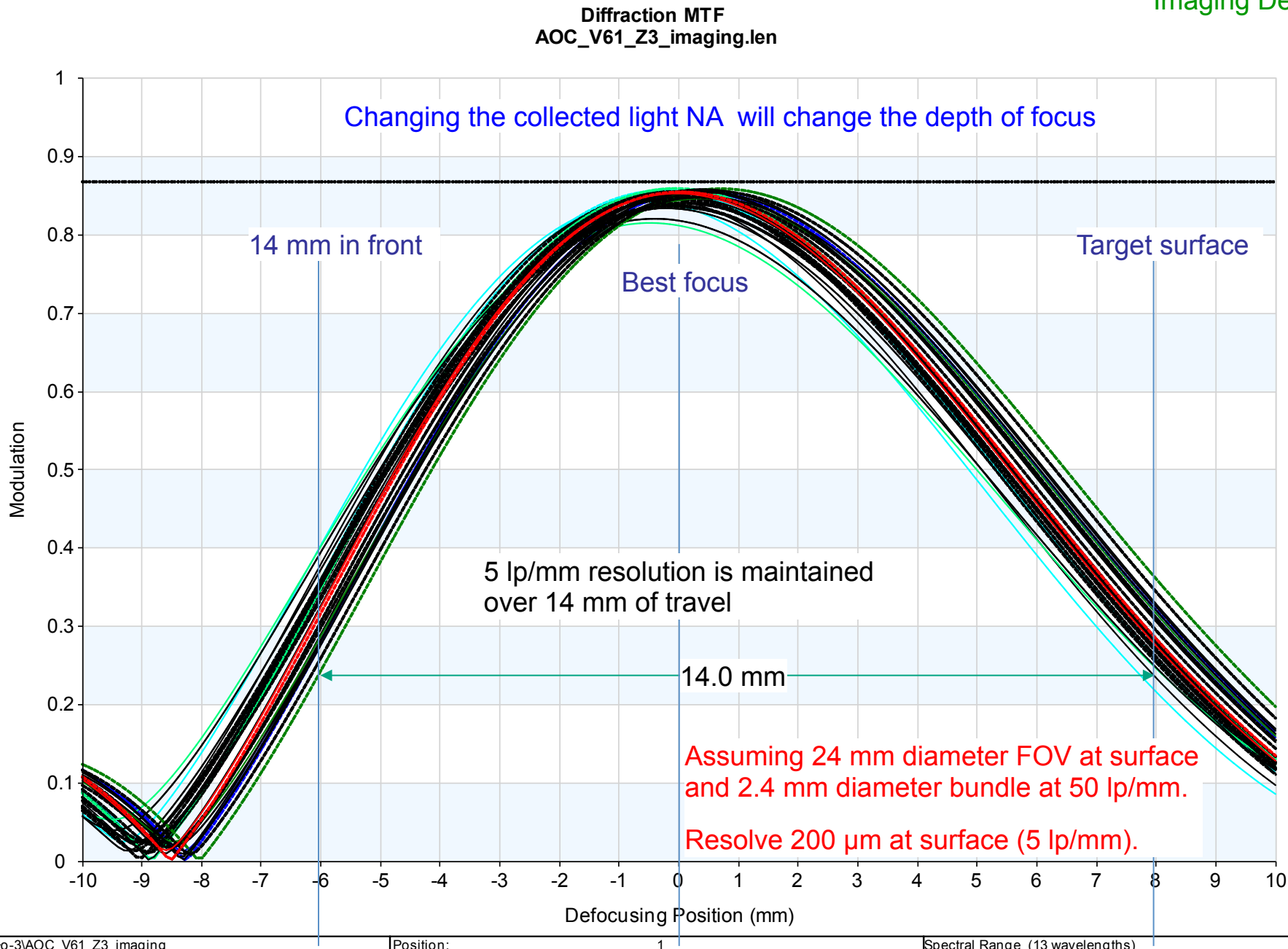


AOC_V61_Z3_imaging.len

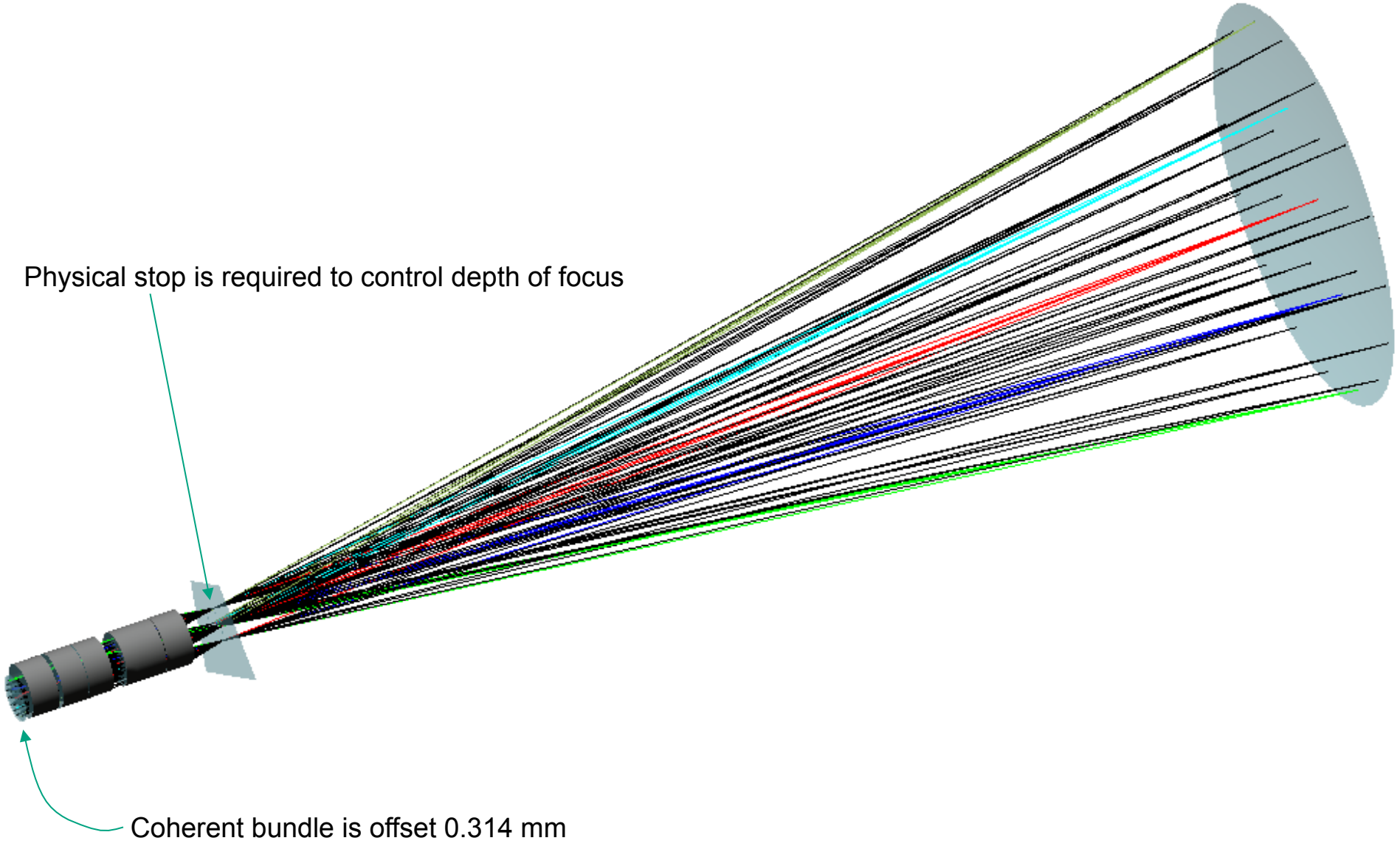
RMM 12-Jun-14



~o-3\AOC_V61_Z3_imaging 12- Jun -14 RMM	Position: 1 Defocusing: 0.000 mm	Spectral Range (13 wavelengths) 1550.0000 - 375.0000 nm Weights: 0 0 4 16 26 37 52 70 79 79 62 21 0

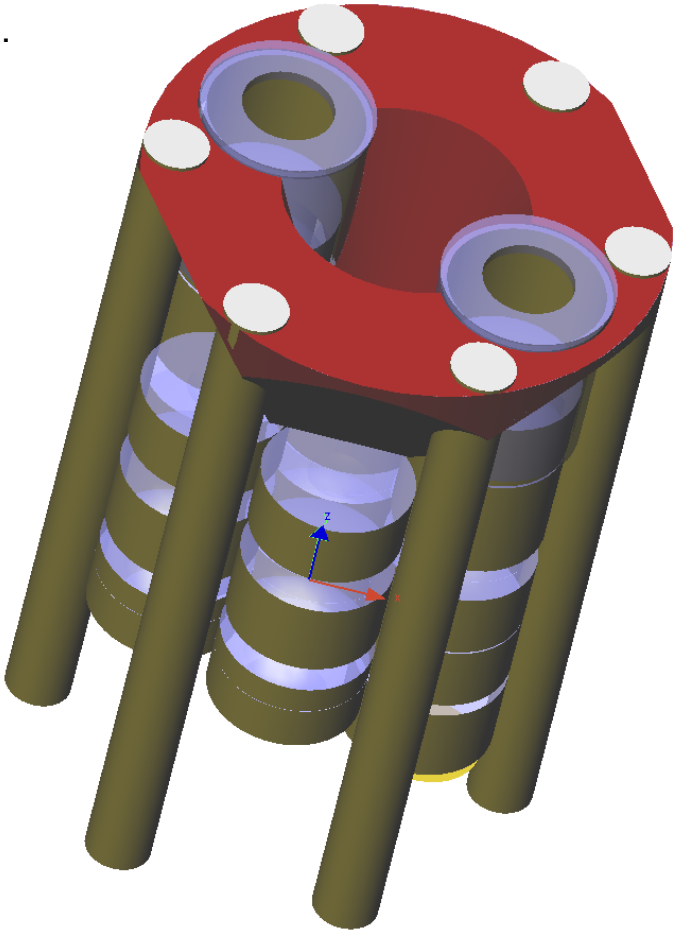


~o-3\AOC_V61_Z3_imaging 12- Jun -14 RMM	Position: 1 Frequency: 5.0 cycles/mm	Spectral Range (13 wavelengths) 1550.0000 - 375.0000 nm Weights: 0 0 4 16 26 37 52 70 79 79 62 21 0


Physical stop is required to control depth of focus
Coherent bundle is offset 0.314 mm

Advantages:

1. Accommodates imaging along with the PDV channels. Imaging does not have to be used for dynamic recording, it could also serve as a surface inspection tool. We have a 1550 nm converter for visible cameras allowing images of surface features surrounding a PDV spot.
2. Each of the 5 fiber arrays can have different rotations to change area coverages.
3. Each mirror facet can have different tilts to change area coverages. Currently using 56º and 61º.
4. AR coatings more efficient than fish-eye, because of fewer curvatures.
5. Each lens stack can have different focal lengths (modular design).
6. This probe accommodates several hundreds of fibers.
7. Data recorded down to 6.5 mm from the zero crossing.



Disadvantages:

1. Zero crossings are shifted ~2.5 mm for 4 of the 5 zones.
2. Must show that imaging is cheap and easy to perform.